WHAT IS CLAIMED IS:

**1.** A microfluidic device, comprising:

a body structure comprising at least one microchannel network and a plurality of ports disposed in the body structure, at least one port being in fluid communication with at least one microchannel in the at least one microchannel network; and,

a manifold comprising at least one manifold channel network and at least one aperture disposed in the manifold, the at least one aperture being in fluid communication with at least one manifold channel in the manifold channel network, the manifold being mated with the body structure, whereby the at least one aperture or one or more manifold channels in the manifold channel network is in fluid communication with one or more of the plurality of ports.

**2.** The microfluidic device of claim 1, wherein the at least one aperture is in fluid communication with two or more manifold channels, wherein at least two of the two or more manifold channels fluidly communicates with a different port.

**3.** The microfluidic device of claim 1, wherein the at least one microchannel network disposed in the body structure extends in a substantially planar dimension and wherein the at least one manifold channel network disposed in the manifold comprises channels extending both horizontally and vertically within the manifold.

**4.** The microfluidic device of claim 1, wherein the at least one microchannel network and the at least one manifold channel network extend in at least horizontal and vertical planes.

**5.** The microfluidic device of claim 1, wherein at least one manifold channel in the at least one manifold channel network disposed in the manifold comprises at least one cross-sectional dimension of at least about 5 μm, 10 μm, 50 μm, 100 μm, 250 μm, 500 μm, 1,000 μm, 5,000 μm, or more.

**6.** The microfluidic device of claim 1, further comprising at least one additional aperture or manifold channel in fluid communication with the at least one

aperture, with the at least one or another manifold channel network, or with the at least one port, for venting air when the device is loaded with one or more reagents or filled with another fluidic material.

**7.** The microfluidic device of claim 1, wherein the at least one manifold channel network and the at least one aperture further comprise at least one bulk viscosity enhancer and at least one electrolyte disposed therein for inducing low electrical resistance within the device.

**8.** The microfluidic device of claim 1, further comprising a controller/detector apparatus configured to receive the microfluidic device, the controller/detector apparatus comprising an optical or an electrochemical detection system and a material transport system, the detection system and the transport system being operably interfaced with the microfluidic device.

**9.** The microfluidic device of claim 1, further comprising two or more manifolds, wherein each of the two or more manifolds interchangeably mates with the body structure for distributing at least one fluid to one or more of the plurality of ports in the body structure.

**10.** The microfluidic device of claim 9, further comprising a controller/detector apparatus configured to interchangeably receive the body structure or each of the two or more manifolds, the controller/detector apparatus comprising at least an optical or an electrochemical detection system, a material transport system, and a body structure or manifold interchange system, the detection system, the transport system, and the body structure or manifold interchange system being operably interfaced with the microfluidic device.

**11.** The microfluidic device of claim 1, further comprising two or more body structures, wherein each of the two or more body structures interchangeably mates with the manifold for distributing at least one fluid to one or more of the plurality of ports in the body structure.

**12.** The microfluidic device of claim 11, further comprising a controller/detector apparatus configured to interchangeably receive the two or more

body structures or the manifold, the controller/detector apparatus comprising at least an optical or an electrochemical detection system, a material transport system, and a body structure or manifold interchange system, the detection system, the transport system, and the body structure or manifold interchange system being operably interfaced with the microfluidic device.

**13.** The microfluidic device of claims 8, 10, or 12, wherein the controller/detector apparatus is automated.

**14.** The microfluidic device of claim 1, wherein the body structure and the manifold are integrated.

**15.** The microfluidic device of claim 14, wherein each of the body structure and the manifold separately comprise at least a first surface, the plurality of ports being disposed in the first surface of the body structure, and the at least one aperture or the one or more manifold channels in the manifold channel network being disposed in the first surface of the manifold, the first surface of the manifold upon integration being mated to the first surface of the body structure such that the at least one aperture or the one or more manifold channels in the at least one manifold channel network are in fluid communication with the plurality of ports disposed in the body structure.

**16.** The microfluidic device of claim 15, wherein the first surface of the body structure and the first surface of the manifold are planar.

**17.** The microfluidic device of claim 15, wherein at least one fluid is flowed in the at least one manifold channel or microchannel networks using one or more fluid direction components comprising one or more of: a fluid pressure force modulator, an electrokinetic force modulator, a capillary force modulator, a gravity force modulator, a magnetic force modulator, a dielectrophoretic force modulator, or a fluid wicking element.

**18.** The microfluidic device of claim 15, wherein at least one fluid is flowed in the at least one manifold channel network using a first gravity force modulator and in the at least one microchannel network using one or more fluid

direction components comprising one or more of: a fluid pressure force modulator, an electrokinetic force modulator, a capillary force modulator, a second gravity force modulator, a magnetic force modulator, a dielectrophoretic force modulator, or a fluid wicking element.

**19.** The microfluidic device of claim 15, wherein the manifold further comprises at least a first alignment structure for aligning the body structure on the first surface of the manifold.

**20.** The microfluidic device of claim 15, further comprising at least one semi-permeable membrane portion disposed between at least a portion of the first surface of the manifold and the first surface of the body structure when the first surface of the manifold and the first surface of the body structure are mated, such that the at least one semi-permeable membrane portion is disposed between the at least one aperture or the one or more manifold channels in the at least one manifold channel network and the plurality of ports disposed in the body structure.

**21.** The microfluidic device of claim 15, wherein the first surface of the manifold is mated to the first surface of the body structure using one or more of: adhesion, heat lamination, bonding, welding, or clamping.

**22.** The microfluidic device of claim 15, further comprising one or more of:

each of the plurality of ports further comprising a rim disposed circumferentially around each port in the first surface of the body structure and an internal surface, wherein at least a portion of the rim and the internal surface of at least one of the plurality of ports comprises a conductive coating; or,

at least one ring, wherein the at least one ring is disposed between the manifold and the body structure and circumferentially around the at least one aperture when the at least one aperture is aligned with at least one of the plurality of ports in the body structure; or,

a gasket disposed between at least a portion of the first surface of the manifold and the first surface of the body structure.

23. The microfluidic device of claim 15, the manifold further comprising a second surface opposite the first surface, wherein the at least one aperture is disposed in the second surface and in fluid communication with the at least one manifold channel in the manifold channel network.

24. The microfluidic device of claim 23, wherein the second surface of the manifold is planar.

25. The microfluidic device of claim 23, wherein the at least one aperture comprises a depth of at least about 1 mm, 5 mm, 10 mm, 100 mm, or more.

26. The microfluidic device of claim 23, wherein the at least one aperture comprises a volume of at least about 1 μl, 10 μl, 100 μl, 1,000 μl, or more.

27. The microfluidic device of claim 23, wherein the at least one aperture further comprises a rim disposed circumferentially around the at least one aperture in the second surface and an internal surface, wherein at least a portion of the rim and the internal surface of the at least one aperture comprise a conductive coating.

28. The microfluidic device of claim 1, wherein the manifold comprises two or more layers.

29. The microfluidic device of claim 28, wherein the two or more layers are bonded, adhered, welded, or clamped together.

30. The microfluidic device of claim 28, wherein the two or more layers are fabricated from at least one polymeric, glass, or ceramic material.

31. The microfluidic device of claim 28, wherein at least two of the two or more layers are fabricated from different polymeric, glass, or ceramic materials.

32. The microfluidic device of claim 28, wherein the two or more layers are approximately the same thickness.

33. The microfluidic device of claim 28, wherein at least two of the two or more layers are different thicknesses.

**34.** The microfluidic device of claim 28, wherein at least one of the two or more layers of the manifold comprises a thickness of at least about 1 μm, 10 μm, 100 μm, 1 mm, 5 mm, 1 cm, or more.

**35.** The microfluidic device of claim 28, wherein the manifold comprises at least about 3, or at least about 5, or at least about 10 layers in which the at least one manifold channel network and the at least one aperture are disposed.

**36.** The microfluidic device of claims 1 or 28, wherein the manifold or the two or more layers of the manifold are fabricated using a process selected from one or more of: injection molding, cast molding, compression molding, extrusion, embossing, and etching.

**37.** A method of distributing at least one fluid to one or more of a plurality of ports disposed in a body structure of a microfluidic device, the method comprising:

loading the at least one fluid into at least a first aperture in a manifold of the microfluidic device, which microfluidic device comprises the manifold and the body structure, wherein the manifold further comprises at least one manifold channel network disposed therein, wherein the first aperture is in fluid communication with one or more manifold channels in the at least one manifold channel network, wherein the first aperture or at least one manifold channel is in fluid communication with the one or more of the plurality of ports, and wherein at least one microchannel network is in fluid communication with the plurality of ports; and,

flowing the at least one fluid using at least one fluid direction component from the first aperture through the at least one manifold channel network such that the at least one fluid is distributed to the one or more of the plurality of ports disposed in the body structure of the microfluidic device.

**38.** The method of claim 37, further comprising flowing the at least one fluid in the at least one microchannel network or the manifold channel network using one or more fluid direction component comprising one or more of: a fluid pressure force modulator, an electrokinetic force modulator, a capillary force

modulator, a gravity force modulator, a magnetic force modulator, a dielectrophoretic force modulator, or a fluid wicking element.

**39.** The method of claim 37, further comprising flowing the at least one fluid in the manifold channel network using a first gravity force modulator and in the at least one microchannel network using one or more of: a fluid pressure force modulator, an electrokinetic force modulator, a capillary force modulator, a second gravity force modulator, a magnetic force modulator, a dielectrophoretic force modulator, or a fluid wicking element.

**40.** The method of claim 37, further comprising providing at least a second aperture or manifold channel in the manifold, wherein the second aperture or manifold channel is in fluid communication with the first aperture, with the at least one or another manifold channel network, or with the one or more of the plurality of ports, for venting air from the microfluidic device during the loading or the flowing steps.

**41.** The method of claim 37, further comprising providing at least a second aperture or manifold channel in the manifold, wherein the second aperture or manifold channel is in fluid communication with the one or more of the plurality of ports, wherein the second aperture or manifold channel comprise at least one bulk viscosity enhancer and at least one electrolyte disposed therein for delivering at least one electrical field to the one or more of the plurality of ports during operation of the device.

**42.** The method of claim 37, further comprising interchanging two or more body structures such that each body structure is sequentially mated to the manifold and flowing the at least one fluid from the manifold to the plurality of ports disposed in each interchanged body structure.

**43.** The method of claim 37, wherein at least one portion of the at least one microchannel network comprises a plurality of parallel microchannels, the method further comprising flowing the at least one fluid from the first aperture into the plurality of parallel microchannels or into one or more ports in fluid communication with the plurality of parallel microchannels.

**44.** The method of claim 43, wherein the plurality of parallel microchannels comprise at least about 6, 12, 24, 48, 96, or more parallel microchannels.

**45.** The method of claim 43, further comprising assaying the at least one fluid for one or more detectable properties in each of the plurality of parallel microchannels simultaneously.

**46.** The method of claim 45, further comprising detecting the one or more detectable properties in at least one common detection region of the plurality of parallel microchannels using at least one detector in or proximal to the plurality of parallel microchannels in the at least one common detection region.

**47.** The method of claim 46, further comprising detecting the at least one detectable signal in each of the plurality of parallel microchannels simultaneously in the at least one common detection region.

**48.** The method of claim 37, wherein the loading step further comprises loading the at least one fluid into the first aperture of each of two or more manifolds of the microfluidic device.

**49.** The method of claim 48, further comprising mating the body structure sequentially to each of the two or more manifolds and flowing the least one fluid from each of the two or more manifolds to the plurality of ports disposed in the body structure of the microfluidic device.

**50.** The method of claim 48, further comprising interchanging the two or more manifolds such that each manifold is sequentially mated to the body structure and flowing the at least one fluid from each interchanged manifold to the plurality of ports disposed in the body structure of the microfluidic device.

**51.** The method of claims 42 or 50, wherein at least one step is automated.

**52.** A method of fabricating a manifold for a microfluidic device, the method comprising forming one or more layers using at least one fabrication process to

comprise at least one aperture disposed in the one or more layers, which aperture is in fluid communication with one or more manifold channel networks disposed in at least one of the one or more layers, wherein the manifold is structurally configured to mate with a body structure of the microfluidic device.

**53.** The method claim 52, the method further comprising bonding, adhering, welding, or clamping the two or more layers together such that the at least one aperture is in fluid communication with the one or more manifold channel networks disposed in at least one of the two or more layers.

**54.** The method of claim 53, the method further comprising forming the manifold to comprise one or more substantially planar layers.

**55.** The method of claim 53, the method comprising forming the one or more layers using at least one fabrication process selected from one or more of: injection molding, cast molding, compression molding, extrusion, embossing, and etching.